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EXAMINER

MARKHAM, WESLEY D

ART UNIT	PAPER NUMBER
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1762

DATE MAILED: 01/29/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/739,477

Applicant(s)

ZHANG, YUEGANG

Examiner

Wesley D Markham

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☐ Responsive to communication(s) filed on ____.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-34 is/are pending in the application.
- 4a) Of the above claim(s) ____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) ____ is/are allowed.
- 6) ☒ Claim(s) 1-34 is/are rejected.
- 7) ☐ Claim(s) ____ is/are objected to.
- 8) ☐ Claim(s) ____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☒ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 18 December 2000 is/are: a) ☐ accepted or b) ☒ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. §§ 119 and 120

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☒ All b) ☐ Some * c) ☐ None of:
- 1) ☒ Certified copies of the priority documents have been received.
 - 2) ☐ Certified copies of the priority documents have been received in Application No. ____.
 - 3) ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.
- 13) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application) since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.
- a) ☐ The translation of the foreign language provisional application has been received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121 since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 2.
- 4) ☐ Interview Summary (PTO-413) Paper No(s). ____.
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____

DETAILED ACTION

1. Claims 1 – 34 are currently pending in U.S. Application Serial No. 09/739,477, and an Office Action on the merits follows.

Priority

2. Receipt is acknowledged of papers submitted under 35 U.S.C. 119(a)-(d) (i.e., the certified copy of priority document JP 11-359579, filed on 12/17/1999), which papers have been placed of record in the file.

Information Disclosure Statement

3. The IDS filed by the applicant on 3/26/2001 as paper #2 is acknowledged, and the references listed thereon have been considered by the examiner as indicated on the attached copy of the PTO-1149 form.

Drawings

4. The formal drawings (4 sheets, 4 figures) filed by the applicant on 12/18/2000 have been received.
5. The drawings are objected to because the TEM image of the carbon nanotubes in Figure 2 is blurry and unclear. A proposed drawing correction or corrected drawings are required in reply to the Office Action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

Specification

6. The title of the invention is not descriptive. A new title is required that is clearly indicative of the invention to which the claims are directed. The following title is suggested: "Method of processing a nanotube using a selective solid state reaction".

Claim Objections

7. Claims 29 and 30 are objected to under 37 CFR 1.75(c), as being of improper dependent form for failing to further limit the subject matter of a previous claim. Applicant is required to cancel the claim(s), or amend the claim(s) to place the claim(s) in proper dependent form, or rewrite the claim(s) in independent form. Specifically, Claim 29 requires that the nanotube be a carbon nanotube, and Claim 30 requires that the nanotube be a boron nitride based nanotube. However, independent Claim 21 (from which Claims 29 and 30 depend) already requires, in part, "forming a top of a carbon nanotube" (see line 1 of the claim). Therefore, Claims 29 and 30 fail to further limit the subject matter of Claim 21.

Claim Rejections - 35 USC § 112

8. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

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9. Claim 30 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

10. Specifically, Claim 30 requires that the nanotube be a boron nitride based nanotube.

However, independent Claim 21 (from which Claim 30 depends) requires that the nanotube be a carbon nanotube (see line 1 of the claim). It is unclear how a nanotube can be both "boron nitride based" and a "carbon nanotube", as boron nitride based nanotubes and carbon nanotubes are mutually exclusive species of nanotubes. Therefore, the scope of Claim 30 is unclear (i.e., because one skilled in the art would not be reasonably apprised of what type of nanotube the applicant intends to claim), and the claim is indefinite under 35 U.S.C. 112, second paragraph.

Claim Observations

11. The phrase "rapidly cooling" in Claims 8 and 26 has been broadly but reasonably interpreted by the examiner to require cooling at a rate high enough / sufficient to cause the nanotube to be separated from the reaction product.

12. After reviewing the applicant's specification, it appears to the examiner that a "single-layer winded nanotube" (Claims 9 and 27) and a "multi-layer winded nanotube" (Claims 10 and 28) are equivalent to a single-walled nanotube and a multi-walled nanotube, respectively, and the claims have been interpreted as such.

Claim Rejections - 35 USC § 102

13. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for a patent.

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

14. Claims 1 – 5, 7 – 9, 11, 13 – 14, 17 – 23, 25 – 27, 29, 31, and 32 are rejected under 35 U.S.C. 102(a) as being anticipated by Zhang et al. ("Controllable method for fabricating single-wall carbon nanotube tips", Applied Physics Letters, August 2000).

15. Regarding independent **Claims 1 and 21**, Zhang et al. teaches a method of processing a nanotube, specifically a method of forming a tip (i.e., a top) of a carbon nanotube (Abstract), the method comprising selectively contacting a selected part of a nanotube with a solid state reactive substance (i.e., a niobium substrate) having an edge (i.e., defined by holes in the substrate) (page 966, col.1, paragraph 2; Figure 2), carrying out a heat treatment of the solid state reactive substance to cause a selective solid state reaction on a contacting region of the selected part of the nanotube and the solid state reactive substance to have the selected part only become a reaction product (i.e., NbC), wherein a boundary between the reaction product and the nanotube is self-aligned to the edge of the solid state reactive

substance (page 966, col.2; page 967, col.2; Figure 2), and separating the nanotube from the reaction product to define a top / end of the nanotube (page 966, col.2, paragraphs 2 and 3; Figure 2(c)). Regarding **Claim 2**, Zhang et al. also teaches selectively contacting a part of the nanotube with the reactive substance (i.e., a niobium substrate) (page 966, col.1, paragraph 2; Figure 2), causing a selective solid state reaction on a contacting region of the selected part of the nanotube and the reactive substance to have the selected part only become a reaction product (i.e., NbC), wherein a boundary between the reaction product and the nanotube is self-aligned to an edge portion of the contacting region of the selected part of the nanotube and the reactive substance (page 966, col.2; page 967, col.2; Figure 2). Regarding **Claims 3 – 5, 22, and 23**, Zhang et al. also teaches that the solid state reaction is caused by heating the reactive substance (Claim 3) by irradiation of a heat ray, specifically an infrared ray, onto the reactive substance (Claims 4, 5, 22, and 23) (Abstract; page 966, col.2, paragraphs 1 and 2; page 967, col.2, paragraph 1; Figure 2(b)). Regarding **Claims 7 and 25**, Zhang et al. also teaches that the step of contacting the selected part of the nanotube with the reactive substance comprises the steps of dispersing the nanotube into an organic solvent, specifically ethanol, to form a dispersion liquid, applying the dispersion liquid onto a surface of the reactive substance, and evaporating the organic solvent from the dispersion liquid to leave the nanotube on the reactive substance (page 966, col.1, paragraph 2). Regarding **Claims 8 and 26**, Zhang et al. also teaches that the nanotube is separated from the reaction product (i.e., the NbC) by rapidly cooling the reaction

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product (page 966, col.2, paragraph 1; page 967, col.2, paragraph 1). Regarding **Claims 9, 11, 27, and 29**, Zhang et al. also teaches that the nanotube is a single-wall carbon nanotube (i.e., a SWCNT) (Abstract). Regarding **Claims 13, 14, 31, and 32**, Zhang et al. also teaches that the reactive substance is a metal (Claims 13 and 31), specifically Nb (Claims 14 and 32) (Abstract; Figure 2 and associated description). Regarding **Claim 17**, Zhang et al. also teaches that the reactive substance is in a solid state. Specifically, Zhang et al. teaches that the "reactive substance" is a perforated Nb substrate, which is a solid (page 966, col.1, paragraph 2). Regarding **Claims 18 and 19**, Zhang et al. also teaches that the reactive substance comprises a substrate having an edge (Claim 18) defined by a hold in the substrate (Claim 19) (page 966, col.1, paragraph 2; page 966, col.2, paragraph 2; Figure 2). Regarding **Claim 20**, Zhang et al. also teaches that the end of the nanotube is a tip (i.e., a top) of the nanotube (Abstract; page 967, col.2, paragraph 1; Figure 2(c)).

16. Applicant cannot rely upon the foreign priority papers to overcome the above rejection because a translation of said papers has not been made of record in accordance with 37 CFR 1.55. See MPEP § 201.15.

17. Claims 1 – 3, 9 – 11, 13, 17, 18, 20, 21, 27 – 29, and 31 are rejected under 35 U.S.C. 102(e) as being anticipated by Jin et al. (USPN 6,283,812 B1).

18. Regarding independent **Claims 1 and 21**, Jin et al. teaches a method of processing a nanotube, specifically a method of forming a tip (i.e., a top) of a carbon nanotube

(Abstract, Col.3, lines 5 – 49), the method comprising selectively contacting a selected part of a nanotube (i.e., the ends of the nanotubes desired to be truncated) with a “solid state reactive substance” (i.e., a solid metal or alloy having a high solid solubility of carbon) having an “edge” (i.e., the top of hot solid metal “40”) (Figure 3B; Col.6, lines 39 – 43 and 66 – 67; Col.7, lines 1 – 8), heating (i.e., carrying out a heat treatment of) the solid state reactive substance (Col.7, lines 1 – 4) to cause a “selective solid state reaction”, specifically the dissolution of a desired length of the carbon nanotube ends by solid state diffusion (Col.7, lines 4 – 8), on a contacting region of the selected part of the nanotube (i.e., the nanotube ends) and the solid state reactive substance to have the selected part only become a reaction product (i.e., by dissolving only the desired length of the ends of the nanotube) (Col.7, lines 4 – 12), wherein a boundary between the reaction product and the nanotube is self-aligned to the edge (i.e., the top of hot solid metal “40”) of the solid state reactive substance (Figure 3B, Col.7, lines 4 – 12). In Jin et al., the “reaction product” is the product formed by the solid state diffusion and dissolution of the carbon nanotube ends into the carbon dissolving metal. Jin et al. does not explicitly teach separating the nanotube from the reaction product to define a top / end of the nanotube. However, the process of Jin et al. involves rubbing the nanotubes against the hot, solid carbon-dissolving metal until a desired length of the ends of the nanotubes are dissolved and the nanotubes are truncated to a desired height (Abstract and Col.7, lines 1 – 14) to define a tip / end of the nanotube (Col.3, lines 40 – 49). This dissolution and truncation (i.e., reduction in length) of the carbon nanotubes would

not occur in the process of Jin et al. unless the nanotubes were separated from the "reaction product" because, if the reaction product remained integral with the nanotubes, the length of the nanotubes would not be reduced and truncation would not occur. In other words, the "reaction product" (i.e., the product formed by the solid state diffusion and dissolution of the carbon nanotube ends into the carbon dissolving metal) is inherently separated from the nanotubes in the process of Jin et al. Regarding **Claim 2**, Jin et al. also teaches selectively contacting a part of the nanotube with the reactive substance (i.e., the hot, solid carbon dissolving metal "40"), causing a selective solid state reaction on a contacting region of the selected part of the nanotube and the reactive substance to have the selected part only become a reaction product, wherein a boundary between the reaction product and the nanotube is self-aligned to an edge portion of the contacting region (i.e., the top of carbon dissolving solid metal "40") of the selected part of the nanotube and the reactive substance (see the discussion of Claims 1 and 21 above). Regarding **Claim 3**, Jin et al. also teaches that the solid state reaction is caused by heating the reactive substance (Col.7, lines 1 – 8). Regarding **Claims 9 – 11 and 27 – 29**, Jin et al. also teaches that the nanotube is a single-walled or multi-walled carbon nanotube (Col.4, lines 56 – 67, and Col.5, lines 1 – 21). Regarding **Claims 13 and 31**, Jin et al. also teaches that the reactive substance is a metal (Col.7, lines 1 – 5). Regarding **Claim 17**, Jin et al. also teaches that the reactive substance is in a solid state (Col.7, line 1). Regarding **Claim 18**, Jin et al. also teaches that the reactive substance comprises a substrate having an edge, specifically the top of hot solid metal "40"

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(Figure 3B, Col.7, lines 4 – 6). Regarding **Claim 20**, Jin et al. also teaches that the end of the nanotube is a tip (i.e., a top) of the nanotube (Figure 3B, Col.3, lines 46 – 48, Col.5, lines 4 – 5).

Claim Rejections - 35 USC § 103

19. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

20. In the alternative to the reasoning presented above in paragraph 18, Claims 1 – 3, 9 – 11, 13, 17, 18, 20, 21, 27 – 29, and 31 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jin et al. (USPN 6,283,812 B1).

21. Specifically, Jin et al. teaches all the limitations of **Claims 1 – 3, 9 – 11, 13, 17, 18, 20, 21, 27 – 29, and 31** as set forth above in paragraph 18, except for a method comprising separating the nanotube from the reaction product to define a top / end of the nanotube. However, the process of Jin et al. involves rubbing the nanotubes against the hot, solid carbon-dissolving metal until a desired length of the ends of the nanotubes are dissolved and the nanotubes are truncated to a desired height (Abstract and Col.7, lines 1 – 14) to define a tip / end of the nanotube (Col.3, lines 40 – 49). Additionally, it is the desire of Jin et al. to truncate the ends of the carbon nanotubes in order to improve the emission properties of carbon nanotube arrays for

use in microwave vacuum tube devices and flat panel field emission displays (Abstract, Col.1, lines 7 – 12, and Col.7, lines 54 – 56). Therefore, it would have been obvious to one of ordinary skill in the art to separate the nanotubes from the “reaction product” (i.e., the product formed by the solid state diffusion and dissolution of the carbon nanotube ends into the carbon dissolving metal) in the process of Jin et al. with the reasonable expectation of successfully and advantageously reducing the length of the carbon nanotubes in the nanotube array of Jin et al. by separating the shortened nanotubes from the reaction product obtained in the shortening process, thereby successfully improving the emission properties of the nanotube array. In other words, it would have been obvious to one of ordinary skill in the art to separate the nanotubes from the reaction product in the process of Jin et al. because the reaction product appears to simply be a by-product of the nanotube truncation process and does not form part of the truncated nanotube array.

22. Claims 6 and 24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zhang et al. (“Controllable method for fabricating single-wall carbon nanotube tips”, Applied Physics Letters, August 2000) in view of either Tanabe et al. (USPN 6,296,894 B1) or Nagashima et al. (USPN 6,101,316).

23. Zhang et al. teaches all the limitations of **Claims 6 and 24** as set forth above in paragraph 15, except for a method wherein the reactive substance (i.e., the Nb substrate) is heated by applying a current between the reactive substance and the nanotube. Please note that this heating process claimed by the applicant is

equivalent to a "resistance heating" process (see page 12, lines 13 – 16 of the applicant's specification). Both Tanabe et al. (Col.1, lines 15 – 39) and Nagashima et al. (Col.6, lines 46 – 49) teach that it was known in the art at the time of the applicant's invention to utilize a resistance heating process to heat a metal object in which an electric current passes through / across the metal object. It would have been obvious to one of ordinary skill in the art to heat the reactive substance (i.e., the Nb substrate) of Zhang et al. by resistance heating (i.e., applying a current between the reactive substance and the nanotubes), as taught by either Tanabe et al. or Nagashima et al., with the reasonable expectation of (1) success, as resistance heating is capable of heating metal objects in general, and the Nb substrate of Zhang et al. is a metal object, and (2) obtaining similar results (i.e., successfully heating the substrate to cause a solid state reaction between the substrate and the carbon nanotube, regardless of whether the substrate is heated by an infrared lamp (as taught by Zhang et al.) or by resistance heating). Please note that the actual method of heating the Nb substrate does not appear to be critical in the process of Zhang et al., so long as the substrate is heated.

24. Claims 10 and 28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zhang et al. ("Controllable method for fabricating single-wall carbon nanotube tips", Applied Physics Letters, August 2000) in view of Jin et al. (USPN 6,283,812 B1).
25. Zhang et al. teaches all the limitations of **Claims 10 and 28** as set forth above in paragraph 15, except for a method wherein the nanotube is a multi-walled nanotube.

Specifically, Zhang et al. teaches that the nanotube is a single-walled nanotube (Abstract). Additionally, the method of Zhang et al. is designed to prepare well-defined nanotube tips for field-emission applications (Abstract; page 967, col.2, paragraph 2). Jin et al. teaches the functional equivalence of SWCNTs and MWCNTs in the art of truncating nanotubes and forming nanotube tips for field / electron emission applications (Abstract, Col.1, lines 7 – 12, Col.4, lines 60 – 67, Col.5, lines 1 – 21, and Col.7, lines 54 – 56). Therefore, it would have been obvious to one of ordinary skill in the art to utilize MWCNTs in the process of Jin et al. instead of SWCNTs with the reasonable expectation of success and obtaining similar results (i.e., successfully preparing well-defined carbon nanotube tips for field-emission applications, regardless of whether the nanotubes are single-walled or multi-walled).

26. Claims 15, 16, 33, and 34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zhang et al. ("Controllable method for fabricating single-wall carbon nanotube tips", Applied Physics Letters, August 2000) in view of Bower et al. (USPN 6,277,318 B1).

27. Zhang et al. teaches all the limitations of **Claims 15, 16, 33, and 34** as set forth above in paragraph 15, except for a method wherein the reactive substance (i.e., the substrate) is a semiconductor (Claims 15 and 33), specifically Si (Claims 16 and 34). However, the process of Zhang et al. functions by performing a solid state reaction between the Nb substrate and the carbon nanotube in contact with the substrate to

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form NbC (i.e., a carbide) (Figure 2; page 967, col.2). Additionally, Zhang et al. teaches that a different solid reactant can be chosen for the process (page 967, col.2, paragraph 2). In other words, the process of Zhang et al. is not limited to using Nb as the solid reactant. Bower et al. teaches that both Nb (as taught by Zhang et al.) and Si are carbide-forming materials that will react with carbon nanotubes to form the associated carbides (Col.2, lines 37 – 67, Col.3, lines 1 – 14). In other words, Bower et al. teaches the functional equivalence of Nb and Si as carbide-forming materials when used in conjunction with carbon nanotubes. Therefore, it would have been obvious to one of ordinary skill in the art to utilize a silicon substrate as the reactive substance in the process of Zhang et al. instead of a Nb substrate with the reasonable expectation of success and obtaining similar results (i.e., successfully reacting the nanotube with a carbide-forming material to form a carbide, regardless of the nature of the carbide-material).

28. Applicant cannot rely upon the foreign priority papers to overcome the above rejections that are based, in part, on Zhang et al. because a translation of said papers has not been made of record in accordance with 37 CFR 1.55. See MPEP § 201.15.

29. Claims 4, 5, 22, and 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jin et al. (USPN 6,283,812 B1) in view of either Schertler (USPN 4,461,665) or Ichinose et al. (USPN 4,224,379).

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30. Jin et al. teaches all the limitations of **Claims 4, 5, 22, and 23** as set forth above in paragraph 18 or 21, except for a method wherein the reactive substance (i.e., the hot solid metal "40") is heated by irradiation of a heat ray onto the solid state reactive substance (Claims 4 and 22), specifically an infrared ray (Claims 5 and 23).

Specifically, Jin et al. teaches that the solid metal is heated (Col.7, lines 1 – 5) but is silent regarding the method of heating the metal. This suggests to one of ordinary skill in the art that the specific method of heating is not particularly critical, so long as the metal is heated. Both Schertler (Col.5, lines 55 – 59) and Ichinose et al. (Col.13, lines 22 – 41) teach that metal substrates / assemblies can be heated by irradiating an infrared ray onto the substrate. It would have been obvious to one of ordinary skill in the art to heat the solid metal of Jin et al. using IR rays (as taught by either Schertler or Ichinose et al.) with the reasonable expectation of (1) success, as Jin et al. is silent regarding the method of heating and both Schertler and Ichinose et al. teach that IR irradiation is a suitable method for heating a metal substrate, and (2) obtaining similar results, regardless of the specific method utilized to heat the solid metal of Jin et al.

31. Claims 6 and 24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jin et al. (USPN 6,283,812 B1) in view of either Tanabe et al. (USPN 6,296,894 B1) or Nagashima et al. (USPN 6,101,316).

32. Jin et al. teaches all the limitations of **Claims 6 and 24** as set forth above in paragraph 18 or 21, except for a method wherein the reactive substance (i.e., the

hot solid metal "40") is heated by applying a current between the reactive substance and the nanotube. Please note that this heating process claimed by the applicant is equivalent to a "resistance heating" process (see page 12, lines 13 – 16 of the applicant's specification). Jin et al. does teach that the solid metal is heated (Col.7, lines 1 – 5) but is silent regarding the method of heating the metal. This suggests to one of ordinary skill in the art that the specific method of heating is not particularly critical, so long as the metal is heated. Both Tanabe et al. (Col.1, lines 15 – 39) and Nagashima et al. (Col.6, lines 46 – 49) teach that it was known in the art at the time of the applicant's invention to utilize a resistance heating process to heat a metal object in which an electric current passes through / across the metal object. It would have been obvious to one of ordinary skill in the art to heat the reactive substance (i.e., the metal substrate "40") of Jin et al. by resistance heating (i.e., applying a current between the reactive substance and the nanotubes), as taught by either Tanabe et al. or Nagashima et al., with the reasonable expectation of (1) success, as resistance heating is capable of heating metal objects in general, and the substrate of Jin et al. is a metal object, and (2) obtaining similar results (i.e., successfully heating the solid metal to cause a carbon dissolution reaction, regardless of the specific method employed to heat the solid metal).

33. Claims 12 and 30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jin et al. (USPN 6,283,812 B1) in view of Cohen et al. (USPN 6,231,980 B1) and either Nakai et al. (USPN 4,389,465) or Henney et al. (USPN 3,811,928).

34. Jin et al. teaches all the limitations of **Claims 12 and 30** as set forth above in paragraph 18 or 21, except for a method wherein the nanotube is a boron nitride based nanotube. Specifically, the nanotubes of Jin et al. are carbon nanotubes (Cols.3 – 4). However, the purpose of the process of Jin et al. is to truncate the ends of nanotubes in order to improve the emission properties of nanotube arrays for use in microwave vacuum tube devices and flat panel field emission displays (Abstract, Col.1, lines 7 – 12, and Col.7, lines 54 – 56). Cohen et al. teaches that boron nitride based nanotubes were known in the art at the time of the applicant's invention (Abstract, Col.2, lines 10 – 29, and Col.5, lines 28 – 43) and can be utilized as field emitters in field emission devices (i.e., the same application as that desired by Jin et al.) (Col.7, lines 53 – 56; Claim 11). Both Nakai et al. (Col.6, lines 36 – 44) and Henney et al. (Col.4, lines 10 – 11) teach that boron nitride is soluble in various metals and/or metallic compounds. Therefore, it would have been obvious to one of ordinary skill in the art to utilize boron nitride based nanotubes in the solid-state dissolution / truncation process of Jin et al. with the reasonable expectation of (1) success, as the process of Jin et al. is utilized to truncate nanotubes (for use in field emission devices) by dissolving the ends of the nanotubes in a material in which the nanotubes are soluble; Cohen et al. teaches that boron nitride based nanotubes can be used in field emission devices; and Nakai et al. and Henney et al. both teach suitable materials in which boron nitride is soluble (and therefore materials that could be used as a hot, solid boron nitride dissolving material “40” in the process of the combination of Jin et al., Cohen et al., and either Nakai et al. or Henney et al.), and

(2) obtaining the benefits of utilizing boron nitride based nanotubes in the process of Jin et al., such as extending the aforementioned process from a single species of nanotubes (i.e., carbon) to multiple species of nanotubes (i.e., carbon and/or boron nitride), thereby increasing the versatility of the truncation process. In performing the boron nitride nanotube truncation process, one of ordinary skill in the art would have utilized one of the materials taught by either Nakai et al. or Henney et al. to have boron nitride solubility so that the boron nitride nanotubes could be successfully dissolved and truncated, as desired by Jin et al.

35. Claims 15, 16, 33, and 34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jin et al. (USPN 6,283,812 B1) in view of Cohen et al. (USPN 6,231,980 B1) and Nakai et al. (USPN 4,389,465).

36. The combination of Jin et al., Cohen et al., and Nakai et al. teaches all the limitations of **Claims 15, 16, 33, and 34** as set forth above in paragraphs 18, 21, and 34.

Specifically, as set forth above in paragraph 34, it would have been obvious to one of ordinary skill in the art to utilize boron nitride based nanotubes in the process of Jin et al., along with utilizing an associated material in which boron nitride is soluble (as taught by Nakai et al.) for solid "40" in the process of Jin et al. (see paragraph 34 above). One of the materials having boron nitride solubility taught by Nakai et al. is Si (Col.6, line 43). Therefore, it would have been obvious to one of ordinary skill in the art to use Si as the reactive substance "40" in the process of the combination of Jin et al., Cohen et al., and Nakai et al. with the reasonable expectation of

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successfully and advantageously using a material (i.e., Si) for the reactive substance "40" that has boron nitride solubility as opposed to carbon solubility, thereby extending the nanotube truncation process from a single species of nanotubes (i.e., carbon) to multiple species of nanotubes (i.e., carbon and/or boron nitride) and increasing the versatility of the truncation process. In making this rejection of Claims 33 and 34 (which depend from Claim 21), the examiner has reasonably interpreted Claim 21 to not require that the nanotube be a carbon nanotube. In other words, the examiner has interpreted Claim 21 to be open to boron nitride based nanotubes. This interpretation is supported by applicant's Claim 30, which also depends from Claim 21 and requires that the nanotube be a boron nitride based nanotube.

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Colbert et al. (WO 98/05920 A1) teaches a variety of methods for cutting and shortening carbon nanotubes. Moloni (USPN 6,452,171 B1) teaches a method of sharpening a nanotube bundle by contacting the bundle with a V-shaped groove in a substrate and heating the substrate to a temperature sufficient to burn-off portions of the nanotube bundle.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Wesley D Markham whose telephone number is (571) 272-1422. The examiner can normally be reached on Monday - Friday, 8:00 AM to 4:30 PM.

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shrive Beck can be reached on (571) 272-1415. The fax phone number for the organization where this application or proceeding is assigned is (703) 872-9306.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0661.



WDM

Wesley D Markham
Examiner
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